TITLE: UK Military Requirements for Unmanned Land Vehicle Combat Engineer Support

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Abstract

The paper describes the operational requirements and methods of achieving remote operation of Combat Engineer Equipments for use by the UK Army during periods immediately prior to combat, possibly during combat and extensively in post conflict clearance operations. The techniques could also be used in peace support or for non-military applications. Unmanned ground vehicles have several potential applications on the battlefield including reconnaissance, mine clearance and other engineer tasks.

The paper examines the teleoperational requirements for the adaptation of existing Combat Engineer Vehicles such as the Chieftain Armoured Vehicle Royal Engineer (CHAVRE), and the Combat Engineer Tractor (CET) and future requirements for service replacement vehicles such as Future Engineer Tank (FET) and Terrier (replacement CET). The benefits of the use of technologies to improve remote control equipment for the combat engineer are discussed with the evolutionary approach of developing vehicles which have greater intelligence, independence, versatility, and which reduce certain manpower tasks at favourable costs savings. The paper discusses specific topics on:- UK Engineer support requirements, direction of UK RLV programme, design philosophy, advantages and disadvantages of using UGVs instead of manned vehicles, safety features and some technology limitations.

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Introduction

DERA land systems department at Chertsey, Surrey, is currently conducting applied research in support of the UK Ministry of Defence (MoD) Operational Requirements branch (OR) for Combat Engr Equipments and Robotic Land Vehicles (ARMY) within the MoDs Applied Research Package 05 (ARP05). This work includes triservice , EOD and RCV's.

The paper describes the operational requirements and methods of achieving remote operation by remote teleoperation adaptation of existing Combat Engineer Vehicles. The Combat Engineer Equipments are for use by the UK Army during periods immediately prior to combat, possibly during combat and extensively in post conflict clearance operations. This is by definition a hazardous environment where operators could be under fire or at risk from a variety of unexploded ordnance. The remote control techniques can also be used in peace support where a variety of dangerous tasks need to be completed to render the area safe.

The engineer equipment programme is broad and includes about 140 projects which are split into various capability areas ranging through bridging, fortifications, mines and demolitions, countermine, explosive ordnance disposal (EOD) and water supply to name but a few. This research is used to assist in defining the requirements for new equipments and hence it eventually informs the procurement process carried out by the MoDPE (DPA by 1 April 99).

Unmanned ground vehicles will have certain applications on the battlefield, for example in reconnaissance, breaching, bridgelaying, obstacle construction and mine clearance. Certain tasks in specific scenarios can be extremely hazardous, hence the use of remote control will certainly reduce the danger to men in some of these situations. In this presentation, remote control using teleoperation is discussed using some examples of demonstrations already successfully carried out.Current technology can already enable manned vehicles to be converted to

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remote operation for tasks where men would be particularly endangered. The introduction of unmanned ground vehicles (UGV) technology should therefore be evolutionary, with the aim of developing vehicles which have greater intelligence, independence and versatility, and which could save manpower preferably at reduced costs.

The idea of robots on the battlefield will conjure up to many, visions of large-walking creatures roaming free and destroying everything they encounter. Whilst the battlefield use of robots of such sophistication is still a long way off and may never be achieved without a man-in-the-loop to provide authoritative command, UGV's of more limited capability are already making an important contribution to the modern army. UGVs with man-in-the-loop control are now widely used for explosive ordnance disposal (EOD) tasks, and have been used in this role for over 20 years.

User Requirements

Over the years, the need for, and scope of, Engineer support on the battlefield has been well established. It is provided by a wide variety of equipment and vehicles, optimised for their specific role and place on the battlefield. Engineers have, and will continue to use, a number of armoured vehicles to provide mobility, counter mobility and survivability support to formations whilst providing protection to their own crews.

The current Chieftain Armoured Vehicle Launched Bridge (CHAVLB) and Chieftan Armoured Vehicle Royal Engineer (CHAVRE) were converted from Chieftain gun tanks in the 1970s and 1980s respectively, to replace their Centurion based predecessors. The Combat Engineer Tractor (CET) - see figure 1, and Engineer tanks all fulfil vital functions within Engineer regiments. It is planned to replace these vehicles in the next 9 years with the Future Engineer Tank (FET) with in-service date of 2004 and Terrier (replacement CET) in 2007/8 and will enable Engineers to provide improved close mobility support to armoured formations as well as carrying out other tasks. Tasks are undertaken throughout the width and depth of the area of operations, and are provided by a range of equipments with complementary characteristics and capabilities. Engineer mobility support tasks include wet and dry gap crossing, obstacle breaching, route opening, route maintenance, countermine and EOD battlefield clearance. Mobility is denied to an enemy through the enhancement of natural obstacles, the construction of man-made obstacles and the blocking of routes. The rapid ability to construct earthworks and defences for all-arms protection is an essential part of survivability support.

It is the aim that the Robotic Land Vehicles research programme will help to enhance the Royal Engineers and other arms capability by improving mobility and counter mobility support to Army armoured formations.

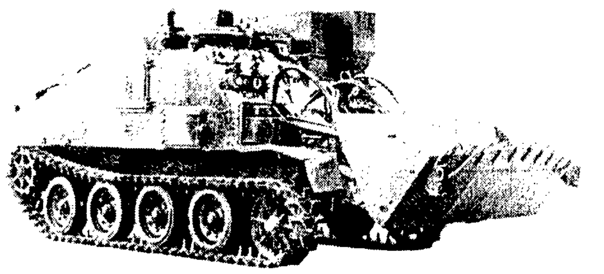

Figure 1 - Combat Engineer Tractor

Why Robotics?

It is probably as well to be clear as to why the military are interested in robotics. The reasons you see here are the main ones, although there may be others. Some advantages of using UGVs instead of manned vehicles are:

Maintaining the technological edge remains just as important as ever, so battle winning operational performance benefits will always remain the prime motivator. The importance of being able to minimise casualties on operations is now greater than in the past but with the acceptance of destruction of the unmanned vehicle. It is not necessarily due to any greater concern for human life, but because we no longer talk in the short term of wars of national survival, at least as far as the UK is concerned. There is the possibility of bolder concepts of operation, because of this reduced risk. Higher performance levels on extended and repetitive operations (where, for example, humans may suffer from fatigue, boredom or stress) and manpower reduction (as robotics compensate for a reduction in manpower without loss of effectiveness).

Conversely, there are disadvantages. Their high cost. A lack of user confidence, acceptance and an increased logistic burden. UGVs are probably less flexible and adaptable than men. Finance is a major driver and any efficiencies that robotics can offer will always be gratefully received.

Direction of UK Robotic Land Vehicle (RLV) programme through DERA

The aims of the robotics research within ARP05 is to provide advice on land robotic issues, maintain DERA's ability to provide such advice, assist in assessing the military worth of different concepts and provide solutions to Urgent Operational Requirements (UORs) and to promote knowledge of land robotics capabilities and its limitations.

In this area which does not attract a large amount of funding compared with for example the US, these aims ensure that amongst other things, the military, can retain an intelligent customer status and that the military OR and PE community are aware of the potential of robotics for future equipments.

Two of the equipment types discussed here today are where DERA have conducted research into teleoperation for remote driving and manipulative type engineer tasks. Other applications for other Engineer vehicles will be likely in the future including remote control of mine detection and mine neutralisation sensor carrying vehicles. The need for teleoperation techniques will most likely require colour and contain elements of mono or stereo vision, augmented reality, virtual reality (VR) or a combination. The programme has so far been concentrating on teleoperation kits for in-service vehicles such as the AVRE and the CET. It is seen as the most likely route for robotics to enter service and gain user acceptance. Acceptance of new technology equipments has always been a challenge to the researcher especially where safety is at risk. The growing requirement these days is to show that the benefits to the user outweighs the cost of development. We are currently investigating technologies that will improve teleoperation capabilities - these are stereo vision, optical flow, communications and image enhancement through augmented reality techniques.

Design Philosophy

The philosophy for the core area of the DERA RLV research programme has been to take the latest available technology and assess its capabilities against the Users requirement. Since UOR's occur from time to time, by assessing the latest technologies and equipments, rapid responses can be made when the need arises to provide appliqué kits for the UOR. The use of such kits allows flexibility where the kit can be removed reasonably quickly from the vehicle and it can then be interfaced with another type of vehicle with minimum of interfacing such as a PC flash disk, e.g. PCMCIA card. Commercial off the shelf equipments are used where ever possible. There must be no interference with the manual operation of the vehicle and a short change over time is required from manual to remote control by, for example switched operation. Design concepts must be space conscious as the controls and interface units must fit into already cramped spaces in the Engineer vehicles. Operator Control Units are required to be fitted into the secondary vehicle. Space is an important consideration and the use of Helmet Mounted Displays or VR systems may help to alleviate this problem. A recent enhancement of the research budget has allowed the programme to investigate future techniques such as novel vision and augmented reality for teleoperation.

Teleoperation kits for AVRE and CET

Appliqué kits for possible UOR use in Bosnia and also as proof of principle for future FET and Terrier programmes were investigated in 1995/96. The robotics remote control system currently being used in the US SARGE programme was purchased and minor modifications were made to suit the UK MoD requirement. using this equipment, the AVRE mineplough and fascine operations - see figure 2, were evaluated, by way of monovision teleoperation to drive the vehicle remotely and carry out the manipulative tasks. Ploughing up mines is an extremely hazardous task and any reduction in risk is welcome. The buried or surface mines can be in various forms from anti-personnel to the larger anti-tank types with explosive contents ranging from 2-10 kilograms. They may well also be booby trapped and liable to explode when approached, disturbed or interfered with. Depth ploughing is used for route clearance and surface clearance ploughs are also used to clear runways or roads of unwanted ordnance and minor obstacles. Remote teleoperation is of great benefit in these situations.

Fascines are bundles of rigid plastic pipes and are used for filling in ditches to enable them to be breached. They are also recoverable but in a combat situation may be left in place. Loading the fascines manually is quite difficult for one operator to complete the task. A selection of carefully positioned "remote" cameras can aid this but the task remains an arduous one. Deployment of the fascines is easier. The tank is driven into position and the restraining chains have to be released. The fascine platform is tilted from the rear and the fascines slide off forward. Up to 3 fascines can be fitted to each vehicle at a time.

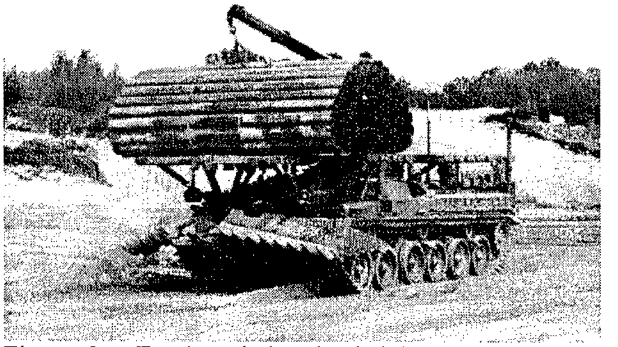

Figure 2 - Fascines being loaded by crane onto the AVRE

Teleoperation for CET has been based on the methodology and hardware used on AVRE. From the AVRE trials, driving functions were not difficult, thus the CET research was aimed at investigating and improving the manipulative tasks. Various trials have been conducted since 1997 with the main technical objective being to investigate digging tasks required in earth moving, the construction of obstacles such as sand banks and tank ditches. Clearance of obstacles was investigated such as filling in NATO standard tank ditches. Other clearance activities require the removal of heavy obstacles, for this, the CET 4-in-1 bucket is ideal for these manipulative type tasks, but not easy to implement because of limited visual perception.

Other reasons for consideration for teleoperation are, use by a single operator, advance selection of cameras and camera positions to enhance views and depth perception., the use of microwave link for a 1-2.5Km line of sight video transmission or relays to provide non line of sight vision to the remote command vehicle. A minimum of three cameras are fitted to the front of the vehicle and one at the rear. The centre front is mounted above the drivers head which improves forward vision by reducing obscuration by the ploughs and bucket. Two side cameras improve side/peripheral vision and allow accurate driving within narrow "safe lanes" or fenced off areas such as minefields or improved digging perception. The rear camera allows accurate and fast reverse driving. Operator control units can be fitted to display single or multi image options.

Operator Control Unit and its functions

The operator control unit (OCU) was selected for its history of performance use on the US SARGE programme. In the UK research programme, it was modified to perform driving and manipulative tasks and consists of a 486 33MHz PC with video LCD display and connections for interface outputs. Driving is via a motorbike handlebar control offering various functions such as steering, accelerator, braking and gear change. Control of the ploughing and fascine operations are done with the joystick. Other functions have been modified to provide the 4 in 1 bucket controls. The bucket can be operated by joystick or by standard bulldozer lever type controls to provide such functions as - raise/lower, digging/dumping, open/close and float/level grading.

Safety

The OCU PC is able to offer many diagnostic capabilities - for our purposes items such as, gear status, vehicle speed, low oil pressure warning, safety status warnings, communication link dropout etc. have been incorporated. Communications for remote links from the command vehicle to the remote vehicle offer control of the remote vehicle by two way radio link. The military vehicle radio, in the case of AVRE/CET is a VHF Clansman and was used to provide command functions such as engine control, steering, and braking. This technique is described in detail in the paper by Mr Peter Gibson.

Safety is paramount when remotely controlling the large vehicles. The computer hardware has a safety unit with watchdog/ command data safety flags. An in vehicle safety cut - off switch is also incorporated. This feature is essential when conducting evaluation trials, some of which do take place at the researcher's site. Some vehicles lose their hydraulic breaking when the engine is switched-off, an important point to remember when considering safety. The software is required to be fail-safe but not safety critical.

Technology limitations

One of the most complex technology areas is the communication link between the remote vehicle and its operator, particularly given the amount of information that needs to be transmitted. Autonomous vehicles, which can 'see' and 'think' for themselves and thus need little operator intervention and only intermittent communication are being considered for the future. However, given the current state of the art, it is realistic to assume that for the foreseeable future all UGVs on the battlefield will rely on visual information of some type being sent from the vehicle to the operator to allow man-in the-loop operations.

High resolution video contains a large amount of data and thus it's transmission over several kilometres in real time demands a large bandwidth. Image compression techniques are possible, but care must be taken to ensure that close to real time video is achieved. Fibre optic cables as the transmission medium for the video link offers real bandwidth advantages and is covert. They do however seriously impair vehicle manoeuvrability especially when reversing, and they are vulnerable to battle damage, accidental snagging and direct physical attack.

Ongoing and future work

Future areas of work at the robotics department at DERA to be covered are: -
Modelling for optimisation of operator perception and awareness, trials of stereo vision kits on the CET, assessment of head mounted displays and LCDs for stereo vision, use of inclinometers to judge slopes, the use of force feedback to "feel" driving and manipulation of the bucket, obscured vision driving, use of limited night vision equipment.

Co-ordination with other nations and groups -

USA - France - SILVER (UK- Industry/Academia special interest group for advanced robotics and intelligent automation). CLAWAR. EU Brite Euram thematic network on climbing and walking robots. The core activity of our research continues to be improvements to in-service vehicles through current and future technologies. It is anticipated that this will gradually change as the robotics trend is tending towards the field of semi-autonomy.

Concluding note

I believe that UGVs will become increasingly important in military applications for RLV tasks as they can be used on hazardous tasks without endangering men.

Reduced levels of manpower in the modern Army need to be compensated for by increased levels of technology if the same or greater level of operational effectiveness is to be achieved. Some repetitive and manpower-intensive tasks, such as convoying, logistic re-supply and security patrolling, could be carried out reliably by remote equipments and for longer periods, and would thus free people for other demanding tasks.

Bearing in mind events from around the world, it seems increasingly likely that the army of tomorrow will find itself involved more and more in operations other than war. Peacekeeping operations, with the intrinsic political unacceptability of loss of life, seems sure to promote the case for using teleoperated UGVs.

The UK sponsor for the UGV work is the Ministry of Defence, Main Building, Whitehall, London. I would like to thank Lieutenant Colonel Ian Blanks, SO1 Engineer, DDOR (Engr&NBC) for assistance in offering advice and material on User requirements.

Any views expressed are those of the author and do not necessarily represent those of the Department/Agency.